GC 2010-71: AN INTROSPECTIVE STUDY ON STUDENTS' MOTIVATION, UNDERSTANDING AND PERFORMANCE IN ENGINEERING STATICS

Habibah Haron, Universiti Teknologi Malaysia (UTM)

I'm an engineer by qualification but a senior lecturer by profession. Currently I'm a postgraduate student in Engineering Education. Have been with Universiti Teknologi Malaysia (UTM) since 1993. My interests and expertise are inclined towards work improvement, efficiency and effectiveness. I did my first degree and Masters Degree in the UK in Manufacturing Engineering and Manufacturing Systems Engineering respectively. During my Industrial training stint I was attached to four international and local manufacturing companies, ranging from light to heavy industries. Was exposed to various management styles and cultures, namely American, British, Japanese and Malaysian. I chose to be a lecturer after completing my Masters for self satisfaction and continuous development by keeping in touch with knowledge and sharing them, especially with future engineers.

Awaluddin Mohamed Shaharoun, Universiti Teknologi Malaysia (UTM)

Marlia Puteh, Universiti Teknologi Malaysia (UTM)

An Introspective Study on Students' Motivation, Understanding and Performance in Engineering Statics

Abstract

Statics is a fundamental engineering course, which many students find difficult [1-3] to understand. This has considerably affected the students' performance in Statics and other follow-on courses, and consequently, disheartened them from pursuing engineering as a career [4, 5]. However, findings from previous researches showed that good academic performance on assessment alone does not necessarily reflect the engineering students' deep understanding of the fundamental concepts [6, 7]. Steif [8]suggested that apart from the universal issues such as the hard to learn concepts, the local culture and students' work habits contribute to this continual problem . In an earlier survey conducted by the authors, most students attributed their performance in Statics to their own efforts in learning. Therefore, this paper investigates the influence of students' motivational factors in learning for understanding and learning for achieving good performance through statistical data analysis and semi-structured interviews. The findings of this research provide a useful insight into students' motivation in the learning of this fundamental engineering course. This will be useful in designing a curriculum that could enhance engineering students understanding and performance and retain them in the programme.

Keywords:

Engineering Statics, fundamental concepts, deep understanding, performance, motivational factors, self-regulated learning

Introduction

Researches in Statics revealed that Statics is a fundamental engineering course, which many students find to be challenging [1-3]. This has considerably affected their performance in the course and other follow-on courses, and consequently, disheartened them to pursue engineering as a career [4, 5]. Studies on engineering students' academic achievement revealed that students who are academically successful do not necessarily have a deep understanding of fundamental concepts [6, 7, 9].

In order to confirm the magnitude of the problem in the Malaysian context the authors had carried out a preliminary study at a public university. The study exposed that the percentage of students not graduating on time and failed to graduate for mechanical engineering was consistently above 20 percent for four consecutive semesters. The high rate is due to poor students' performance in the first year, which was contributed by the inferior results in Statics that was offered as the first fundamental engineering course. It was identified that Statics has the highest failure rate for almost all semesters when compared to other science and engineering courses taken by the mechanical engineering students. The highest percentage of Statics failure rate was recorded at 45 percent, and the lowest at 13 percent for the semesters shown in Figure 1.0. Some 19% of these students had to repeat the course three times before obtaining a pass and thereby being able to move on to the follow-on courses. Meanwhile, 15% of the students who had failed Statics and have poor cumulative points average (CPA) were either terminated or withdrew from the program [6].

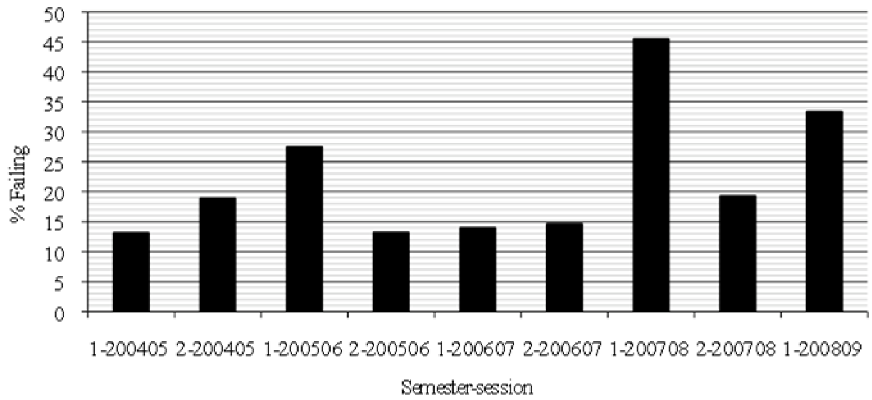

Figure 1.0 Percentage of students failing Statics per semester.

A concept test was given to a sample of the Mechanical engineering students to evaluate their concept understanding. The Statics Concept Inventory [10] was adopted with permission from the developer. Results obtained showed similarity with the U.S data in terms of the most and least scored concepts. The result also revealed that some students who had performed well (scoring grade 'A') in their summative Statics evaluation obtained low concept test scores similar to those students who had failed in the summative Statics evaluation [11]. This illustrates that students' inability to grasp the concepts is not necessarily reflected in their course grades, consistent with claims made by other researchers in Engineering Education that *engineering students who are academically successful often lack deep understanding of fundamental concepts* [7, 9].

Subsequently, the authors distributed a survey to 131 students, and interviewed several students and Statics lecturers to identify potential reasons for the challenges in learning and understanding Statics. Data collected and analyzed indicated that students' learning beliefs and choices of learning strategies were perceived to be the main contributing factors for the poor students' performance and understanding of Statics concepts [11].

Motivation and Academic Performance

The authors' preliminary findings are found to be coherent with the literature on learning and academic performance, specifically on students' self-efficacy and control of learning that influence their academic performance. Self-efficacy represents students' beliefs of their performance capability in a particular domain; whilst, control of learning reflects students' perception on having internal control of their own learning and effort [12]. Both self-efficacy and control of learning beliefs are part of motivation scales commonly found in the literature.

According to Kizilgunes [13], considerable research in education and educational psychology has revealed that motivational variables are highly related to students' learning. Bandura was quoted in suggesting that students' motivation, including their self-efficacy, is related to the use of learning strategies that influence their academic achievement [13, 14]. Meanwhile, Schunk [15] advocated that motivation is necessary for learning to be meaningful and it promotes self-regulated learning (SRL). SRL directs learners' thoughts, feelings and motivated behavior toward the attainment of their goals in learning [15-17]. Greene and

Azevedo[18] in their paper used the concepts expounded by Pintrich and Zimmerman. Pintrich described SRL as a constructive process, where students' set goals based on their past experiences and current environments. Meanwhile, Zimmerman described SR learners as metacognitively, motivationally, behaviorally, and socially active participants in the learning process, which involves acquiring and modifying knowledge, skills, strategies, beliefs, attitudes and behaviours, and is influenced by the learners' identity [19].

As students hold the ultimate responsibility for their own learning [20], and learning Statics demands students to achieve both deep understanding and good performance, this paper discusses the influences of the motivational factors on students' concept test scores and Statics summative scores. It describes only one part of a more comprehensive study that investigates the SRL influences on Statics learning. Suggestions for future research are also offered.

The Conceptual Framework for Assessing Motivation

There are many different models and perspectives in the research carried out on college and university students' motivation and learning [12, 14, 21]. Two generic perspectives are student approaches to learning (SAL) and information processing (IP) approach, characterized by bottom-up approach (in-depth qualitative interviews with students) and top-down approach (using quantitative methods to measure psychological constructs and theories in cognitive and educational psychology) respectively [12]. The SRL perspective, which is more reflective of current theory and research, has replaced the IP perspective. Pintrich [12] elaborated that SRL perspective includes cognitive, motivational, affective and social contextual factors.

SRL perspective assumes that students can [12]:

i. Be active learning participants in the learning process and construct their own meanings, goals, and strategies.
ii. Monitor, control, and regulate certain aspects of their cognition, motivation, behaviour and environment.
iii. Set goals, criterion or standards to assess their learning process.
iv. Self-regulate their cognition, motivation and behaviour to mediate the relations between person, context and performance.

SRL conceptual framework based on the four assumptions outlined above classifies four phases and four areas for regulation. According to Pintrich [12], the four phases are planning and goal setting; monitoring; controlling and regulating; and reacting and reflecting. The four areas for regulation are cognition, motivation/affection, behaviour and social context. SRL models emphasize the importance of integrating both motivational and cognitive components of learning [14].

The Motivated Strategies for Learning Questionnaire (MSLQ) was developed to assess the four perspectives of SRL in academic contexts [12]. Although MSLQ was not designed to assess all components of the framework, it was designed to be operational at course level, with the assumptions that students may have different motivation and may use different strategies for different courses. MSLQ has been widely used in many countries in investigating students' motivation and learning strategies in relation to academic performance [20]. These make MSLQ a suitable base instrument for this study.

Research Methodology

The influence of students' motivational factors in learning for understanding and learning for achieving good performance is investigated through statistical data analysis and semi-structured interviews. Data were collected at four institutions of higher learning in Malaysia; one from the north (named as A), one from the south (B) and two from the central (C and D) regions. The criteria for selection of the four institutions were based upon commonality of the syllabus and textbook used, and the assessment and teaching methods adopted by each institution. Samples from engineering undergraduate students taking Statics were randomly selected, and participation was voluntary. There were over 600 respondents, of which were 81% males and 19% females. 73% of these students were between 17 to 20 years of age, whilst the remaining 27% were above 21 years old.

Three types of data were collected: students' performance in Statics, students' understanding of Statics concepts and their motivated learning strategies in learning Statics. Data for students' academic performance were their Statics scores (the summative score available at the end of every semester), collected before the start of the following semester. The score consists of marks from final exams, tests and assignments. Meanwhile, data set for students' understanding of Statics concepts was their concept scores obtained from the concept tests conducted. The concept test measures students' ability to use core Statics concepts. Data on students' motivated learning strategies was measures of students' responses on the self-report survey. Both concept tests and motivated learning strategies survey were administered together with the demographic survey before the final exams.

Instrument

The Statics Concept Inventory was adopted with permission to measure students' understanding of Statics concepts. It was developed by Paul Steif of Carnegie Mellon University and his collaborators [10]. The 27 multiple-choice questions that represented nine distinct concepts in Statics (listed in Appendix 1) had been used to test over 6000 students at more than 20 universities in the US. The test is available online but for the purpose of this study it was administered using paper and pencil method to get more feedback from the respondents.

The self-report survey used in the study was adapted from the Motivated Strategies for Learning Questionnaire (MSLQ), which was developed by Paul Pintrich and his associates of the University of Michigan [22]. It was designed to measure college students' motivational factors and their use of different learning strategies in college courses. The instrument consists of two constructs: motivational and learning strategies. For the purpose of this study, items in the questionnaire had been changed to suit to Statics and the Malaysian context. The total number of items in the questionnaire was also reduced from 81 to 58 but maintained under the appropriate construct subscales. Responses were scored using a 4-point Likert scale, from 1 (not at all true of me) to 4 (very true of me). The reliability values for the motivation subscales before and after factor analysis was carried out are enclosed in Appendix 2. The factor analysis resulted in the following subscales, which was renamed accordingly:

1. Motivation – Study goals and value; anxiety; learning beliefs and self-efficacy.
2. Learning strategies – Critical thinking and elaboration; organizing and memorizing; persistence and regulation; study effort; meta-cognitive regulation; help seeking.

However, only the motivation subscales in relation to the Statics and concept scores are discussed in this paper.

Results and Analysis

The demographic survey distributed include questions on the number of times the respondents have taken Statics, their goals in taking the course, the factors they believe could influence their performance in Statics, and their general thoughts in Statics classes. The feedback showed that about 3% of the respondents took Statics more than twice, 14% had taken twice and the majority (83%) was taking it for the first time.

Choices of whether students' goals in learning Statics were a combination of to pass (G1), score (G2) and/or to gain understanding (G3) indicated the following (as a percentage of respondents):

1. 62.1% focused on gaining understanding (G3),
2. 43.8% aimed to score Statics (G2),
3. 19.7% targeted to pass (G1),
4. 8.5% aimed to pass and score (G1 and G2),
5. 10.3% aimed to pass and gain understanding (G1 and G3), and
6. 18.6% targeted on both gaining understanding and scoring high marks (G2 and G3).

The results implied that the majority of students put priority in gaining understanding when they learn Statics, followed by scoring instead of just wanting to pass the course. Comparing the number of times students took Statics and the three learning goals, all student categories showed emphasis on gaining understanding when learning Statics. Even students who took Statics more than twice put priority in understanding the course rather than merely getting a pass (Table 1). A Chi-square test for independence (with Yates Continuity Correction) indicated a significant association between students who targeted to gain understanding and perform well in Statics, λ^2 (1, n = 614) = 77.2, p = .00, phi = -.36.

Table 1. Number of times taking Statics vs. goals of learning (choices were a combination of to pass, score and/or to gain understanding)

No. of times taking Statics	Percent (%) of total respondents	To pass, G1 (%)	To gain understanding, G3 (%)	To score, G2 (%)
Once	83	19.2	48.8	39.1
Twice	14	4.7	8.4	4.5
More than twice	3	0.3	1.8	1.6

Factors that could influence students' performance in Statics include both intrinsic (interest, effort, ability, understanding of Statics concepts) and extrinsic (coursework marks, teaching methods, lecturer's attitude, and friends). Students who perceived all four intrinsic factors as influencing their performance in Statics were 10% of the total respondents, as opposed to 4% who believed all four extrinsic factors as the factors that influence their performance. Table 2 shows the contribution in percentage of each factor. The top three factors are their effort in studying, followed by their understanding of the concepts and their interest in learning the course.

Table 2. Factors influencing students' performance

No.	Influencing factors	Percentage (%)
1.	Effort	20
2.	Understanding	17
3.	Interest	14
4.	Ability	12
5.	Teaching method	12
6.	Lecturer's attitude	9
7.	Friends	8
8.	Coursework	7
9.	Other factors	1

As for the general feelings in Statics class, there were 70% of the respondents who felt motivated to learn, but 5% of them were not confident of their ability to do well. On the contrary, 16% of the total respondents who were not confident felt motivated.

The descriptive, correlation and multiple regressions analyses were carried out on the dependent (DV) and the independent variables (IV). The DVs are Statics scores and concept test scores as measures of students' performance and concept understanding in Statics respectively. Whereas the IVs are the motivation subscales: study goals and values, anxiety, and learning beliefs and self-efficacy. Preliminary analyses were already performed to ensure no violation of the assumptions of normality, linearity, multicollinearity and homoscedasticity for the parametric inferential analyses to be carried out.

Table 3. Descriptive Statistics and Pearson Correlations of DV and IV

Variables	N	Mean	Standard Deviation	1	2	3	4	5
1. Statics score (%)	521	69.43	16.09	-				
2. Concept score (%)	625	30.68	14.38	.371**	-			
3. Study goals and values	609	23.27	3.31	.061	.069	-		
4. Anxiety	612	10.80	2.59	-.224**	-.106**	.208**	-	
5. Learning beliefs and self-efficacy	609	20.10	3.43	.325**	.231**	.464**	.022	-

**. Correlation is significant at the 0.01level (2-tailed).

Table 3 illustrates the descriptive statistics and correlations of the variables. The number of respondents (N) for each variable varies, especially much less for Statics score. This is due to the unavailability of the raw scores from one of the institutions that was only able to release their students' grades. Nevertheless, the minimum value for both Statics and concept scores were 0%, whilst the maximum values were 100% and 81% respectively.

Table 3 shows moderate positive correlations between Statics and concept scores (r = .371, n = 521, p < .001), and between Statics score and learning beliefs and self-efficacy (r = .325, n

= 495, $p < .001$). There is also a negative correlation between Statics score and anxiety ($r = -.224$, $n = 497$, $p < .001$), indicating a higher level of anxiety is associated with lower Statics score. Another pair is a moderate positive correlation between learning beliefs and self-efficacy subscale and study goals and values subscale ($r = .464$, $n = 609$, $p < .001$). The associations between concept score and anxiety show a weak negative correlation ($r = -.106$, $n = 601$, $p < .005$), and a weak positive correlation with learning beliefs and self-efficacy ($r = .231$, $n = 598$, $p < .001$).

Regression model analyses were performed, testing the predictive value of the three motivation subscales (IVs) on students' Statics and concept scores (DVs). The multiple regression analyses using the method Enter (Standard) were done separately for each dependent variable, and the results are presented accordingly. Tables 4.1 to 4.3 are related to the multiple regression analysis for the concept score, whilst Tables 5.1 to 5.3 are for the Statics score.

Table 4.1. Multiple Correlation variables: Concept score

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.257[a]	.066	.061	13.93

a. Predictors: (Constant), Total learning beliefs and efficacy, Total anxiety, STUDY Total goals and TASK Value

b. Dependent Variable: %Tot concept score

Table 4.2. Independent Variables significance: Concept score

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	8153.959	3	2717.986	14.008	.000[a]
	Residual	115253.9	594	194.030		
	Total	123407.8	597			

a. Predictors: (Constant), Total learning beliefs and efficacy, Total anxiety, STUDY Total goals and TASK Value

b. Dependent Variable: %Tot concept score

Table 4.3. Correlation coefficient and Independent Variables significance: Concept score

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	18.973	4.683		4.051	.000	9.775	28.171					
	STUDY Total goals and TASK Value	-.110	.201	-.025	-.545	.586	-.505	.286	.069	-.022	-.022	.730	1.370
	Total anxiety	-.591	.227	-.106	-2.609	.009	-1.037	-.146	-.106	-.106	-.103	.944	1.059
	Total learning beliefs and efficacy	1.028	.190	.245	5.405	.000	.654	1.401	.231	.217	.214	.765	1.307

a. Dependent Variable: %Tot concept score

Table 4.1 shows the multiple correlations of all IVs with the concept score as low ($R = .23$). It also shows that the IVs could explain only about 7% of the variance in the Statics score.

However, Table 4.2 indicated that the regression is highly significant F (3,594) = 14.008, $p <$ 0.001. It implies that this model is a significant fit of the overall data. Table 4.3 shows that anxiety is negatively and significantly associated to the concept score, whilst study goals and values subscale has no significant association. The learning beliefs and self-efficacy regression coefficient is highest, positive and highly significant, 1.028 (95% CI = .65 to 1.40), implying that the regression coefficient for the population where the samples were derived from are positive, $t = 5.41$; $p < .001$. The Beta values indicate that learning beliefs and self-efficacy subscale makes the largest unique contribution (beta = .25) and anxiety subscale makes a statistically significant contribution (beta = -.106). These indicate that when:

- Learning beliefs and self-efficacy variable increases by one standard deviation, concept score will increase by about 4%.
- Anxiety increases by one standard deviation, concept score decreases by about 2%.

Table 5.1. Multiple Correlation variables: Statics score

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.402[a]	.162	.157	14.77	.162	31.612	3	491	.000

a. Predictors: (Constant), lEARNING BELIEFS & SELF-EFFICACY, ANXIETY, STUDY GOALS & VALUES

b. Dependent Variable: % Statics marks

Table 5.2. Independent Variables significance: Statics score

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	20692.318	3	6897.439	31.612	.000[a]
	Residual	107131.5	491	218.190		
	Total	127823.8	494			

a. Predictors: (Constant), lEARNING BELIEFS & SELF-EFFICACY, ANXIETY, STUDY GOALS & VALUES

b. Dependent Variable: % Statics marks

Table 5.3. Correlation coefficient and Independent Variables significance: Statics score

Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	95% Confidence Interval for B		Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Lower Bound	Upper Bound	Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	57.286	5.453		10.506	.000	46.572	67.999					
	STUDY GOALS & VALUES	-.306	.235	-.063	-1.305	.193	-.768	.155	.061	-.059	-.054	.730	1.370
	ANXIETY	-1.357	.264	-.218	-5.137	.000	-1.877	-.838	-.224	-.226	-.212	.944	1.059
	lEARNING BELIEFS & SELF-EFFICACY	1.688	.222	.360	7.617	.000	1.253	2.124	.325	.325	.315	.765	1.307

a. Dependent Variable: % Statics marks

Table 5.1 shows the correlation of all IVs with the Statics score ($R = .40$). It also shows that the IVs could explain about 16% of the variance in the Statics score. In Table 5.2 the regression is highly significant F (3,491) = 31.612, $p < 0.001$. It implies that this model is a significant fit of the overall data. Table 5.3 shows that anxiety is negatively and significantly associated to the concept score, whilst study goals and values subscale has no significant association. The learning beliefs and self-efficacy regression coefficient is highest, positive and highly significant, 1.688 (95% CI = 1.25 to 2.12), implying that the regression coefficient for the population where the samples were derived from are positive, $t = 7.62$; $p < .001$. The Beta values indicate that learning beliefs and self-efficacy subscale makes the largest unique contribution (beta = .36) and anxiety makes a statistically significant contribution (beta = -.22). These indicate that when:

- Learning beliefs and self-efficacy variable increases by one standard deviation, Statics score will increase by about 6%.
- Anxiety increases by one standard deviation, Statics score decreases by about 4%.

Semi-structured interview

Students from each institution were invited to volunteer for interview sessions. However, only students from institution A came forward voluntarily. The other three institutions, the author had to approach the students at random. A total of eleven students, 5 from institution A, 1 from institution B, 2 from institution C and 2 from D, were interviewed. Students were asked about their general thoughts in learning Statics, what motivates them to learn and what goals they set in learning Statics.

All five students from institution A described that getting a good grade in Statics is their main concern. They believed they can perform well by putting in a lot of effort in studying and practicing the problem solving questions in the textbook. The students value comradeship and were motivated by each other during their learning time together.

The student from institution B described his confidence in scoring Statics examinations. He did a lot of exercises that the lecturer prepared for the class. His goal was in getting a good grade. His self-confidence provided the motivation to work hard.

One of the students from institution C felt that Statics is not a difficult course. She had done Basic Mechanics whilst in college during her matriculation program. She was confident to do well in Statics and could easily understand what was taught in class. The other student from the same institution but from a different class felt differently. He felt Statics is difficult and could not understand what was taught in class. Due to this he lost his confidence and believed that he would not do well in the exams.

One student from institution D had taken Statics twice. He felt more confident the second time around because he could understand it better. He described that the lecturer who had explained the concepts more clearly contributed to the better understanding. He became more motivated to perform well in Statics. The other student from the same institution had taken Statics more than twice. She explained that she lacked motivation and would like to skip the course if it was allowed. She contributed her poor performance and understanding to her poor basic skills in Mathematics.

Discussion

The research findings based on statistical analyses and semi-structured interviews are discussed here. Results from the statistical analyses on the demographic survey showed that:

i. Students' utmost goal in learning Statics is to gain understanding, instead of merely wanting to get through the course.
ii. Repeating students too put priority in understanding the course material.
iii. Students believe that success is dependent on intrinsic values, mostly on the effort. Thus, indicating that they believe in being responsible for success.
iv. The majority of students are motivated to learn Statics.

Statistical results showed that the motivation variables could only explain 16% variance in students' performance and 7% variance in concept understanding. This could mean the other 86% and 93% respectively is contributed by other factors like learning strategies and students' background. Further analyses are being carried out and will be discussed in future articles.

Regression analyses on the dependent and independent variables showed that learning beliefs and self-efficacy subscale is the main predictor in students' Statics and concept test scores. Students who believe they can learn and are confident in their academic ability, and able to control their own learning and effort are more likely to score in the assessments. Thus, implying that students' understanding of Statics concepts and performance in Statics are significantly dependent on learning beliefs and self-efficacy. However, the finding showed this influence is more on students' performance compared to their understanding. This could mean that students are able to control their learning strategies, resulting in good performance based on assessment scores, mainly regarding calculation questions. Questions of this nature could be solved more easily with a lot of practice. Concept understanding would be more dependent on the teaching methods, which students would have less control of. Further analyses would have to be carried out to confirm this and identify other reasons for the different effects.

Another finding showed that anxiety is a significant factor of influence but the association is weak and negatively related to both concept and Statics scores. This indicates that the more anxious the student is, the lower scores they obtained in assessments, indicating poorer understanding of Statics concepts and performance in Statics assessment. There are strategies like self-talk, where students can use to control their anxiety and negative affections [12]. Pintrich [12] quoted anxiety researchers on other motivational strategies like defensive pessimism and self-handicapping. Defensive pessimism could help students increase their effort to perform better. In contrast, self-handicapping strategies could result in decreasing effort in studying and procrastination in learning or completing assignments. Therefore, it can be assumed that the negative association between anxiety and scores in the findings reflects that students use more negative motivational strategies with higher level of anxiety. This assumption is to be further investigated.

It was also revealed from the analyses that the correlation between concept understanding and Statics performance is highly significant but only moderately associated. This implies that there is a relationship between students' understanding and performance, better understanding leads to better performance and vice-versa. Further analyses will need to be carried out to identify the nature of the relationship, whether students need to understand Statics concepts to perform well in assessments, or it is a prerequisite to pass the course, and at what percentage does understanding explain the variations in students performance.

Results from the semi-structured interviews showed that students have different learning goals: to pass, to score and to understand what they learn in Statics. They described understanding the learning material as a factor of confidence and motivation in learning Statics, and consequently, these contribute to good performance. The students also described some learning strategies that they use in Statics, namely peer learning and solving textbook exercises. A student related prior knowledge in Mathematics skill as an important factor in understanding and learning Statics.

Results from the semi-structured interviews support the results from statistical analyses. It can be concluded from this study that motivation plays an important role in students' Statics academic performance, which is a difficult fundamental course in engineering. Students' learning beliefs and self-efficacy will encourage them to put effort in understanding what they learn and in performing well in the course. Anxiety should be avoided as it negatively influences the students. Understanding helps increase students' confidence, consequently their motivation to perform well in Statics.

Conclusion

It can be concluded from this study that:

1. The motivation subscales are only about a quarter fraction of the variance explained in the scores.
2. Learning belief and Self-efficacy that reflects students' confidence in their academic ability and control of learning and effort is the main predictor of their concept understanding and performance in Statics.
3. Further analysis is required to understand the nature of the relationship between concept understanding and Statics performance.

Implication of the study to education includes a suggestion to Statics lecturers to help motivate their students by encouraging them to believe in their academic capability and putting effort in learning the course. The lecturers can create interesting activities in class so as not to lose the students' interest, positive goals and general motivation. They should emphasize on concept understanding in delivering the course content, inline with the students' aspiration. This suggestion is on top of providing them with problem-solving questions to practice and construct further understanding. Assessment system should reflect the effects of teaching method that emphasizes concept understanding on their performance and other learning outcomes.

Additional suggestions include the following:

1. Further analyses should also include the relationships between motivation subscales and scores for the different students' achievement groups. This could indicate which independent variables are strong predictors to the variance in understanding and performance for the different student groups.
2. A further research is recommended to look at why the study goals and values subscale is not significant, and negatively associated with the concept and Statics scores, which is in contrast with results from other studies on motivation [12, 14].
3. Experimental study measuring the same motivation variables can be carried out to see the effects of any teaching intervention program.
4. Similar research could also be carried out on other fundamental engineering courses to compare findings with this study.

Finally, this study differ from other studies in the following aspects:

1. The study compares the influences of the motivation predictors on two related dependent variables.
2. The instrument was adapted to suit the Malaysian context and the course nature, and revealed new factor groupings.
3. Other studies on Statics focus on the teaching and content delivery aspects.

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Appendix 1: Nine Concepts in the Statics Concept Inventory [10]

1. Free body diagram
2. Newton's 3rd Law
3. Static equivalence of combinations of forces and couples
4. Directions of forces at roller
5. Direction of forces at pin-in-slot joint
6. Direction of forces between frictionless contacting bodies
7. Forces using variables and vectors
8. Limit on the friction force and its trade-off with equilibrium conditions
9. Equilibrium conditions

Appendix 2: The Reliability Values for Motivation Subscales

MSLQ motivation subscales [12] (before factor analysis)	**Cronbach's Alpha**	**Adapted motivation subscales (after factor analysis)**	**Cronbach's Alpha**
Intrinsic goals	.562	Study goals and values	.766
Extrinsic goals	.567	Anxiety	.640
Task value	.633	Learning beliefs and self-efficacy	.750
Learning beliefs	.498	-	
Self-efficacy	.699	-	
Test anxiety	.580	-	